



## Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at <http://about.jstor.org/participate-jstor/individuals/early-journal-content>.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact [support@jstor.org](mailto:support@jstor.org).

## STELLAR PARALLAX.

---

BY PROFESSOR F. P. LEAVENWORTH.

---

Since the time of KEPLER, numerous attempts have been made to detect the parallactic displacement of the stars. The earlier attempts were unsuccessful because the instruments employed were far too crude to detect so minute a displacement. Of the many methods tried, there are undoubtedly four, and perhaps six, which may be relied upon to yield real values for the parallax where the latter is not smaller than one-tenth of a second. These are :

- (1) Observations of zenith distance with a zenith instrument, for absolute parallax.
- (2) Observations of Right Ascension with a transit instrument.
- (3) Observations of difference of Right Ascension with a transit instrument.
- (4) Observations with a heliometer.
- (5) Observations with an equatorial.
- (6) The photographic method.

Until recently the results obtained with the meridian instruments have not been encouraging. The large probable errors and the discrepancies between different observers show the results, in most cases, to be practically worthless. However, the recent methods used by Dr. BELOPOLSKY and especially by Professor KAPTEYN, give results which are apparently comparable with the best values of the heliometer.

It is now my purpose to discuss these methods with the hope of arriving at some conclusion as to which is best adapted to the problem of parallax. In comparing them, these three criteria will be employed as far as possible:

*First.*—Accuracy of an observation.

*Second.*—Freedom from unknown constant errors.

*Third.*—Rapidity and convenience of observation.

Probably the best means of comparing the accuracy of the different methods is by means of the probable errors of single observations, provided the time spent in making the observation

is considered. The following probable errors have been taken from the best authorities at hand, and are probably not far from the best that can be done with the respective instruments:

|                                    |             |
|------------------------------------|-------------|
| (1) Zenith distance,               | $\pm 0''.4$ |
| (2) Observed Right Ascension,      | $\pm 0.3$   |
| (3) Difference of Right Ascension, | $\pm 0.25$  |
| (4) Heliumeter,                    | $\pm 0.20$  |
| (5) Equatorial,                    | $\pm 0.10$  |
| (6) Photography,                   | $\pm 0.15$  |

From this it seems that observations with the equatorial give the smallest probable error. However, this small value is only for moderate distances of the comparison star.

Another test of the accuracy may be made by comparing the average probable error of the final value of the parallaxes. The following table gives the comparison between the results for the six methods, using all the good observations which have been made.

|                           | No. of<br>Stars Used. | Average<br>Probable Error. |
|---------------------------|-----------------------|----------------------------|
| (1) Zenith distance,      | 7                     | $\pm 0''.09$               |
| (2) Observation of R. A., | 9                     | 0.08                       |
| (3) Difference of R. A.,  | 16                    | 0.03                       |
| (4) Heliumeter,           | 33                    | 0.02                       |
| (5) Equatorial,           | 25                    | 0.04                       |
| (6) Photography,          | 27                    | 0.03                       |

In this test the heliometer appears to have the advantage; but there is not much choice between the last four methods. However, the test is not perfectly fair, as the number of measures going into each determination of parallax is not considered, being not at hand. In fact, it is probable that the above superiority of the heliometer is partly due to the greater number of observations used in determining the parallax of the first magnitude stars. Evidently the last four methods may be relied upon to furnish a real value of the parallax, provided there is no constant error to vitiate the results, and provided the real parallax is not less than one-tenth of a second.

That constant errors exist is lamentably evident. One has only to glance over a list of parallax results to see that there are great discrepancies. As examples of these, OTTO STRUVE obtained for  $\alpha$  *Tauri* a parallax of  $0''.52 \pm 0''.06$ , while ASAPH HALL obtained for the same star  $0''.10 \pm 0''.03$ . Again, BALL'S

value for 6 (B) *Cygni* is  $+0''.48 \pm 0''.05$ , where HALL obtains  $-0''.02 \pm 0''.01$ . When, however, we consider the minuteness of the angles measured, the results taken as a whole are really in fine accord. Out of ninety measures made on twenty-three stars, sixty-four differ from the arithmetical mean (for each star) less than one-tenth of a second.

There seems to be, in equatorial measures, a greater tendency to constant error, than in the other best methods. Where the greatest differences between results are found, usually the equatorial has been employed. When also two co-ordinates are measured by the same observer, the results very frequently do not agree. To be sure the other methods can not be exposed to the same test, for usually only one co-ordinate is measured. Where several comparison stars are observed with the heliometer, or by photography, the agreement is much better. There is, however, sufficient discrepancy between the results to cause us to question whether the differences are due to constant error or to parallax in the comparison star itself. Repeated measures by different observers will make evident to what extent the parallax is diminished by the parallax of the comparison star.

For rapidity of observation the meridian method, at first glance, appears to offer the most decided advantages, as it takes only a few moments to make the observation as the star crosses the meridian. It must be remembered, however, that the observer must wait until the star is on the meridian, and unless a large number of stars are included in his list it will be necessary for him to spend considerable time in waiting. Practically, however, the same inconvenience should be found in all observations of parallax, since it is always advisable to make the observations at about the same hour-angle. The photographic method offers decided advantages in time saving. The time of exposure is usually about five minutes. If two exposures are taken, as is customary, there will be a little over ten minutes given to the actual observation, and the plate will contain the images of a number of comparison stars.

Again, photography and the heliometer give the greatest latitude for choosing desirable comparison stars. There is, however, this difficulty in the photographic method, that the comparison stars must be selected in groups of two, symmetrically placed with regard to the primary star.

To sum up, therefore, the first or absolute method of observ-

ing zenith distances has up to the present time furnished few reliable observations. More may be expected of it since the discovery of the periodic variation in latitude.

The second method of observing absolute Right Ascensions appears to be lacking in accuracy, except when applied to stars very near the pole. It has this advantage, however, that even though the measures prove worthless for parallax, they should give fine values of Right Ascension.

The third method consists in observing with the transit instrument the difference of Right Ascension between the star and suitable comparison stars. A chronograph is used for observing the time of transit and various precautions taken. By this means Professor KAPTEYN has obtained results that agree well with other measures, and have small probable errors.

Professor HALL has measured the difference of Right Ascension with the equatorial, by means of the micrometer, with the driving clock running, and has obtained good results. Where the comparison star is so distant that the micrometer cannot be used, the difference of time, as in comet measures, might be employed. The difference of Declination may also be measured with the micrometer of the transit instrument, just as is done with the equatorial.

The fourth method—by means of the heliometer—has been considered, until recently, by far the best method for determining parallax. It holds this high position for the reason that comparatively large distances can be measured with as great an accuracy as small ones. The probable error of a distance of 3000'' seems no greater than for a distance of 30''. For this reason the number of available comparison stars is greatly extended, and the convenience of selection greatly increased. However, the rarity and cost of this instrument is against it. Also, on account of the smallness of the object-glass, the fainter comparison stars cannot be used.

The equatorial has many points of advantage and some of disadvantage. The great objection, perhaps, is the difficulty of obtaining a number of suitable comparison stars. In many cases a near companion cannot be found. Very seldom are there two or more companions. Now, the accuracy of observation is an inverse function of the distance, so that observers (making, perhaps, an exception of Professor HALL) cannot usually obtain sufficiently accurate measures where the distance is much greater

than 100". If suitable comparison stars were clustered within 30" of the star, the equatorial method would furnish unequalled advantages. Where proper motion has been discovered in the brighter component of a double star, observations of position angle and distance give unequalled accuracy. There should be no objection to the comparison star under such circumstances. The angular nearness of the star is accidental. The proper motion, in course of time, will make the companion a distant object.

The photographic method is considered by many to be the coming method, if indeed it is not already the *present* method. The results obtained by RUTHERFURD-JACOBY and by PRITCHARD seem equal to the best; where their results are compared with other measures there is usually a close agreement, and, where no other measures have been made, the photographic parallax is almost without exception very small—a strong indication of accuracy. However, there are two circumstances which mar the otherwise perfect beauty of their results. They are, first, the discrepancy between PRITCHARD's and JACOBY's values for the parallax of  $\mu$  *Cassiopeia*; second, the large parallax obtained by JACOBY from two RUTHERFURD photographs of  $\beta$  *Cygni*. The latter parallax was found to be erroneous, by recent heliometer measures made at Yale University. For the parallax of  $\mu$  *Cassiopeia* it curiously happens that two other observers agree, one with PRITCHARD, the other with JACOBY, as follows :

|                    |                     |
|--------------------|---------------------|
| OTTO STRUVE,       | $0''.33 \pm 0''.06$ |
| RUTHERFURD-JACOBY, | $0.28 \pm 0.02$     |
| SCHWEIZER,         | $0.08 \pm 0.06$     |
| PRITCHARD,         | $0.03 \pm 0.02$     |

The apparent accuracy of these photographic results is surprising. One would think that in bisecting large and ill-defined spots, as the brighter stars appear to be under the microscope, large probable errors and constant errors also would be likely to occur. However, Professor PRITCHARD's measures show that bisections can be made with a probable error less than  $\frac{1}{100}$  of the diameter of the image. Thus, a spot 20" in diameter may be bisected with a probable error of two-tenths of a second.

To my mind the real advantage of this over other methods lies in the convenience and accuracy with which comparatively

large distances may be measured. It is like the heliometer in this respect, with the added advantage that in fine weather a large amount of material may be stored away to be worked up at leisure.

UNIVERSITY OF MINNESOTA, July, 1894.

---

## CAN ORGANIC LIFE EXIST IN THE SOLAR SYSTEM ANYWHERE BUT ON THE PLANET *MARS*?

---

[A letter from a citizen of *Mars*, found in a meteorite which fell in the rooms of the A. S. P.]

---

Communicated by M. CAMILLE FLAMMARION.

---

In the following discussion I hold to the principle that, in explaining any phenomena taking place elsewhere than in *Mars*, we must not assume the existence of new and unknown forces and properties of matter. The more our knowledge of the universe progresses the more we become convinced that the phenomena observed on *Mars* are only repeated, on a smaller or a grander scale, in every nook and corner of infinite space.

One of the very first points to be examined in considering the conditions of habitability of a world, is evidently the question of the stability of beings and of things, and at the same time the allied question of their freedom to move about. It is essential that a man must not be too heavy, nor yet too light. Too great levity would prevent all fixity in the work of his hands—and perhaps all stability in his character, even. Too great gravity would chain him to the soil. It is essential that all useful or agreeable things, dwellings, furniture—everything, in short—should be in harmony with the muscular force of a man, with his stature, his weight, etc. Here, for example, an object falling from the top of an edifice traverses 1.84 mètres during the first second of its fall.\* This is a necessity of the first importance. Suppose, for instance, that bodies, instead of falling with this safe slowness, were attracted by a violent force and were precipitated in a brutal descent two or three times more rapid! In such a case it would be impossible to build houses without

---

\* The editor has translated the Martian measures into terrestrial ones.